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PROGRESS REPORT

Elk Population Dynamics & Breeding Biology

GRAVELLY-SNOWCREST MOUNTAINS

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JOB PROGRESS REPORT

RESEARCH PROJECT

STATE:	Montana		
PROGRAM NO:	W-100-R-3	TITLE:	Wildlife Program
ELEMENT NO:	I	TITLE:	Wildlife Management in Montana by Ecoregion
PROJECT NO:	2	TITLE:	Wildlife Management in the Southwest Montane Ecoregion
OBJECTIVE:	5	TITLE:	Gravelly-Snowcrest Mountains Elk Study
JOB NO:	1	TITLE:	Elk Study Planning and Coordination

Period Covered: July 1, 1994 - June 30, 1995

Prepared by: Kenneth L. Hamlin

Michael S. Ross
Michael S. Ross

Approved by: Terry N. Lonner
Joel G. Peterson

Date: December 31, 1995

Since this is a Progress Report only, results presented herein are not necessarily final and may be subject to change. For this reason, the information contained in this report may not be published or used for other purposes without permission of the Director.

OBJECTIVE

Assist with the compilation and evaluation of existing databases on several elk herds in Montana. Coordinate and recommend research, management studies, and procedures which will provide for more effective management and a better understanding of elk population dynamics.

METHODS

Published and unpublished data continued to be compiled and evaluated. Meetings with MFWP biologists, wildlife managers, and planners were continued to obtain their viewpoints and knowledge. This information will continue to be synthesized with the aid of the computer programs SAS, Dbase, POSIM (Mooney and Lonner 1978), and TELDAY (Wildlife Div. MFWP 1986) to better organize existing databases and evaluate elk management in Montana.

RESULTS AND DISCUSSION

Coordination with Montana Fish, Wildlife and Parks' biologists and wildlife managers was continued to address future management and research needs for elk. Response was given to a variety of requests for information and/or advice on elk management and research. Known-age elk jaws for check station aging boards were provided for several people. A presentation on elk and deer trends in Montana was presented at the combined elk and deer workshop in Sun Valley, Idaho.

Substantial amounts of time were spent providing information and consultation to reporters, teachers, school classes and individuals, and state and federal biologists and administrators.

RECOMMENDATIONS

This aspect of the overall study should be continued in accordance with the objectives and methods stated in the Application for Federal Aid for this research effort.

LITERATURE CITED

Mooney, E. L., and T. N. Lonner. 1978. POSIM-1 General Wildlife Population Simulator. Pps. 631-640. In H. J. Higland, N. R. Neilson and L. G. Hulls Eds. Proc. 1978 Winter Simulation Conf., Miami, FL., Dec. 4-6, 1978. 1,051 pp.

SAS Institute, Inc. 1985. SAS user's guide: statistics. Version 5 ed. SAS Inst., Inc., Cary, NC. 956 pp.

Wildlife Division. 1986. TELDAY user's manual. Montana Department of Fish, Wildlife and Parks, Helena. In Revision.

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INTRODUCTION

Elk (*Cervus elaphus nelsoni*) management in Montana during the 1980s was primarily directed toward increasing elk numbers and maintaining a diversity of choice in elk hunting opportunity. In earlier years, diversity of choice was maintained by either-sex elk hunting. In 1963, 67% of Montana's hunted elk habitat was open to season-long either-sex hunting. More recently, season-long either-sex hunting has declined (to 1% of elk habitat by 1985), and diversity of choice has been maintained by a diversity of regulations among hunting units (Wildlife Division, MFWP, 1985). Also, managing elk populations within the bounds of landowner tolerance has received greater emphasis.

The any-antlered bull regulation remained widespread, but an increasing number of hunting units were restricted to branch-antlered bull hunting. In 1981, only one hunting district (HD 324) was restricted to branch-antlered bull harvest. By 1985, seven hunting districts (HDs 320, 322, 323, 324, 326, 330, 333) had branch-antlered bull regulations and two were branch-antlered bull after an either-sex quota was reached (HDs 424, 442). In 1989, 28 hunting districts (most in southwestern Montana) and portions of 2 others had branch-antlered bull regulations.

Depending on the area, the branch-antlered bull regulation resulted from concerns over low calf/cow ratios and the long-term biological effects of yearling bulls siring most of the calves or from some hunters wanting to harvest a larger bull. MFWP cautioned hunters that few bulls older than 2½ years of age would be harvested following implementation of this regulation.

Low observed calf:cow ratios in the Gravelly-Snowcrest Mountains during the winters of 1979-80 and 1980-81 (18-35 calves:100 cows versus 55-68:100 during 1970-75, Chrest and Herbert 1980 and 1981), coincided with low antlered bull:cow ratios. Available evidence suggested that low proportions of mature bulls in elk populations might negatively affect calf production and/or survival and population size (Hines and Lemos 1979, Prothero et al. 1979, and Smith 1980). Concern over the observed low calf:cow and bull:cow ratios resulted in changes in hunting regulations in HD 324 during 1981. The early archery season was eliminated, and the kill during the general elk season was limited to branch-antlered bulls. The branch-antlered bull regulation was also implemented in HDs 323, 326, and 330 during 1983 and HD 325 and the northern portion of HD 327 during 1987. The early archery season was restored in HD 324 during 1988.

In 1990, a brow-tined bull regulation was implemented in areas that previously had a branch-antlered bull regulation. Thirty hunting units had brow-tined bull regulations in 1990 and 38 in 1992. This regulation is an attempt to reduce the degree of illegal mortality of yearling or "spike" bulls experienced under branch-antlered bull management (Hamlin and Ross 1990b, DeSimone and Vore 1992).

This study was initiated in January 1984 to assess the role and importance of various hunting strategies on elk population characteristics and dynamics. Emphasis has been directed toward breeding biology, reproductive success, calf recruitment, seasonal distribution, movements, and habitat use. Effect of various hunting strategies on hunter success, attitudes, and other factors is also evaluated.

OBJECTIVES

1. Determine the effects of alternate hunting regulations and harvest rates on elk population dynamics and habitat use.

2. Test the hypothesis that when mature bulls (2+ years) comprise less than 5% of an elk population during the breeding season, the net reproductive success will be less than when compared to when the population has greater than 5% mature bulls.

3. Assist biologists with evaluation of existing elk population data and utilize the results from this study to better understand elk population dynamics and manage harvests.

STUDY AREA

Because of low observed calf:cow and bull:cow ratios, the popularity of the area for hunting, and the changes in hunting regulations already in place, the Gravelly-Snowcrest Mountains in southwestern Montana were selected as the primary study area. In 1984 and 1985, work was concentrated on elk that winter on the Madison-Wall Creek Wildlife Management Area (WCWMA) south of Ennis (Lonner and Schladweiler 1985). Elk that winter in the Cherry-Morgan area just north of Wall Creek were also captured and marked. The physiography and vegetation of this area have been described by Eustace (1967) and Gniadek (1987).

In 1986, work was expanded to include elk that wintered on the Blacktail Wildlife Management Area (BTWMA) southeast of Dillon. In Spring 1989, the study area was expanded by marking elk that winter on the Robb-Ledford area, the Warmsprings area, and the Basin-Sage Creek area (Hamlin and Ross 1990a). During this report period, elk were captured and marked on the WCWMA, BTWMA, Cherry-Morgan area, Robb-Ledford area, Greenhorn Mountains, and Blacktail Ridge. The expanded study primarily involves current MDFWP hunting districts 323, 324, 325, 326, 327, and 330 (Fig. 1).

METHODS

Methods employed were similar to those reported previously (Lonner and Schladweiler 1987, Hamlin and Ross 1990b).

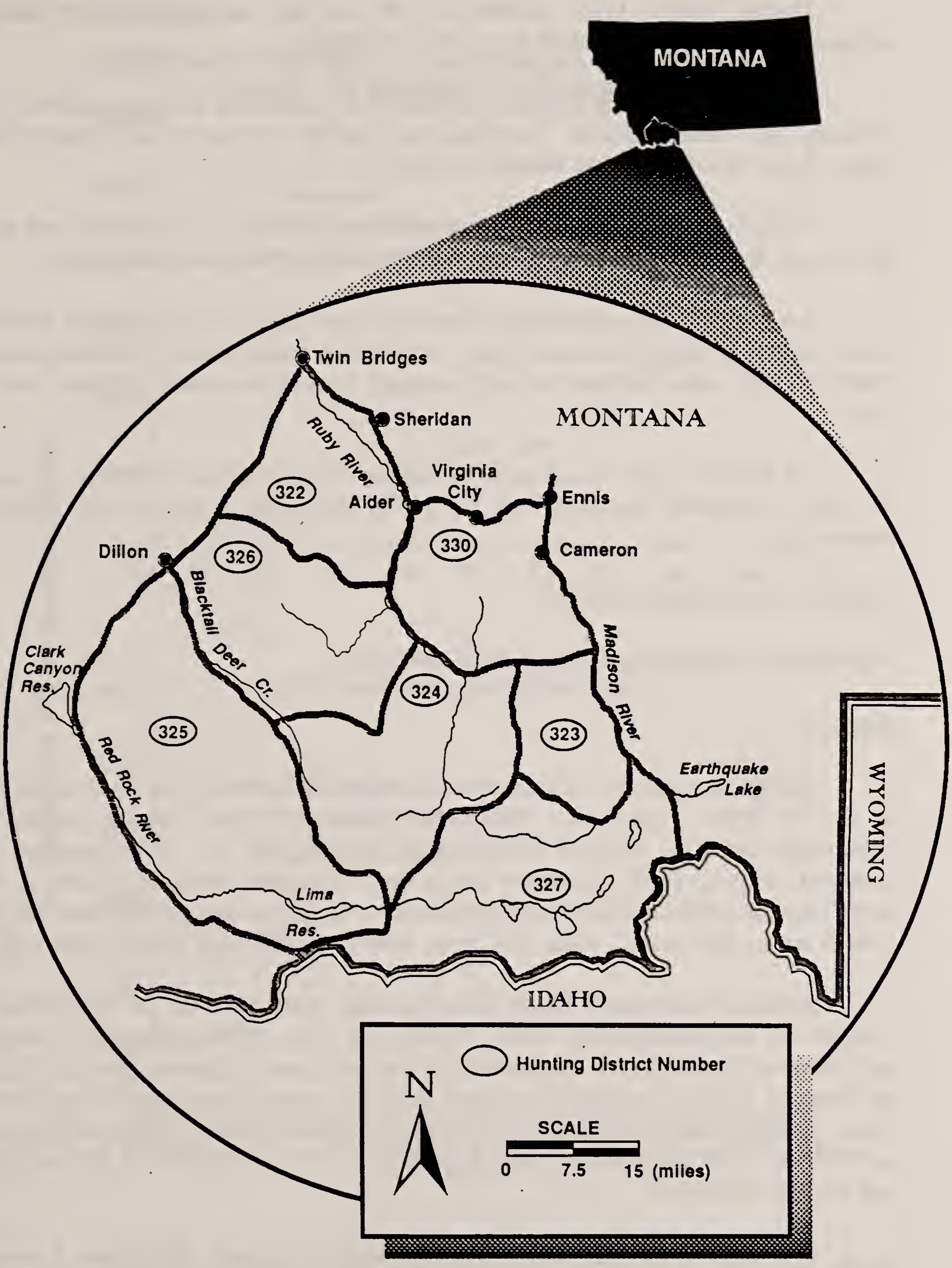


Figure 1. Location of hunting districts within the Gravelly-Snowcrest study area.

During March 1995, capture of 49 elk was accomplished by helicopter netgunning. One male calf died as a result of capture.

Radio-transmitter collars and eartags were placed on 35 male calves, 7 adult females, and 3 female calves. Neckbands and eartags only were placed on two female calves. One female calf was released unmarked.

To help establish herd range on undersampled areas, we captured and marked three adult females on Blacktail Ridge and three in the Greenhorn Mountains.

An incisor was collected from each elk older than two years during 1994-95 at check stations or from other mortalities. Age was assigned based on cementum analysis (Gilbert 1966) and compared to ages assigned by eruption-wear (Quimby and Gaab 1957).

As in prior years, blood samples collected from captured elk were measured at the MSU Veterinary Research Lab for blood chemistry, whole blood, and disease parameters.

RESULTS AND DISCUSSION

Population Characteristics

Numbers

Trends in numbers of elk observed during aerial surveys from 1947 to the present in the WCWMA vicinity and from 1948 in the BTWMA vicinity indicated that populations increased between 1993-94 and 1994-95 (Fig. 2). Total numbers of elk observed for the Gravelly-Snowcrest Range were the highest recorded (Table 1). We do not believe the population increased significantly, but that counting conditions were better than in most other years. Some past trend surveys significantly undercounted elk.

Population estimates made using hunting mortality rate of radio-transmitter collared elk and classification ratios (Hamlin and Ross 1990b) indicated a post-season population of 10,453 elk for the Gravelly-Snowcrest complex during 1994-95. This may be closer to a "true" population estimate than this method has provided for the past 2 years. Past population estimates provided by this method were: 5,058 in 1987-88; 6,293 in 1988-89; 7,358 in 1989-90; 9,819 in 1990-91; 7,303 in 1991-92; 15,149 in 1992-93; and 14,110 in 1993-94.

Whatever method is used to estimate population trend, all indicate a consistent upward trend since 1984. It is possible that the high harvest of 1994 may have slowed population growth.

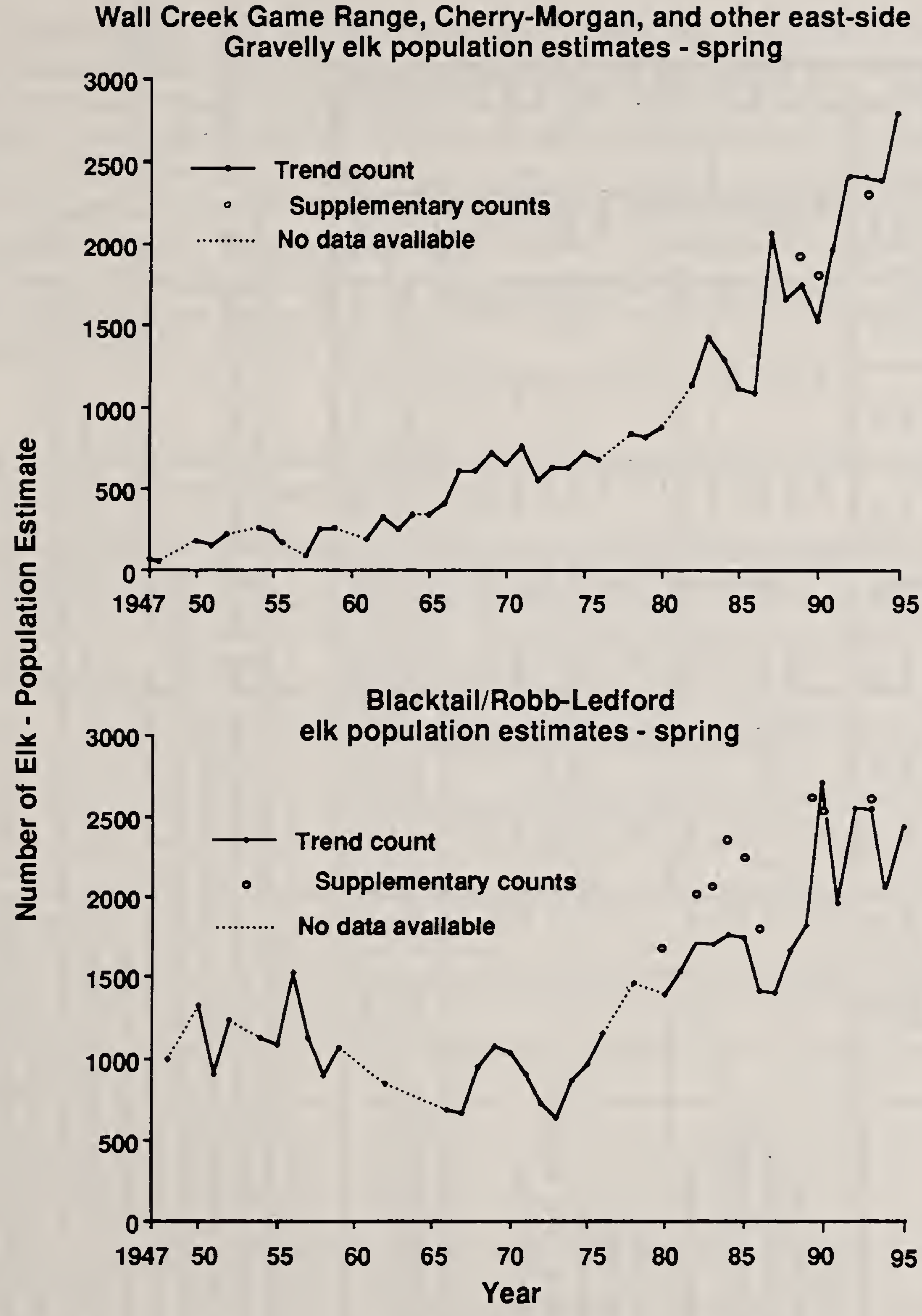


Figure 2. Trends in numbers of elk observed during winter aerial surveys of the east side of the Gravellys area and the Blacktail-Robb-Ledford Wildlife Management Areas, 1947-1995.

Table 1. General locations of elk observations and counts for the winters of 1984-85 through 1994-95.

	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91[b]	1991-92	1992-93	1993-94[b]	1994-95
Axolotl Lake Area	33	97	80	14	0	0	114	218	226	194	126
Cherry-Morgan Creeks Area	414	150	623	233	260	512	444	791	717	529	533
Madison-Wall Creek Game Range	664	805	1,233	1,182	1,401	880	1,249	1,373[c]	1,343	1,591	2,002
Missouri Flats-West Fork Madison	---[a]	35	134	132	91	157	162	32	123	77[h]	52
Total for east side of Gravellys	1,111	1,087	2,070	1,661	1,752	1,549	1,969	2,414[c]	2,409	2,391	2,713
North Centennial Valley	57	19	62	57	0	0	0	0	0	0	191
South Centennial Valley	--[a]	---[a]	---[a]	---[a]	---[a]	310	93	71	27	401[i]	82
Blacktail & Robb-Ledford	1,740	1,416	1,403	1,663	1,820	2,719	1,918	2,517[d]	2,510	2,045	2,457[j]
Greenhorn Mtns. & Lower Ruby River	---[a]	323	432	463	317	458	418	514	512	276	567
Little Sage-Basin Creeks Area	---[a]	199	365	322	490	537	442	840[e]	756	546	1,463[k]
Blacktail Ridge	---[a]	---[a]	189	273	425	493	284	815[f]	933	359	595
Sweetwater Hills	--- [a]	---[a]	---[a]	---[a]	---[a]	---[a]	---[a]	145	98	116	93
Total Blacktail-Centennial-Greenhorns	1,797	1,957	2,451	2,778	3,052	4,517	3,155	4,902[d,e,f]	4,836	3,743	5,448
Grand Total	2,908	3,044	4,521	4,439	4,804	6,066	5,124[b]	7,316[g]	7,245	6,134[b]	8,161[l]

[a] No flights were made over these areas.

[b] Because of wide dispersal during winter 1990-91 and 1993-94, a greater than usual portion of the elk were missed during aerial counts.

[c] A group of 477 elk counted near Wall Canyon are not included because we believe they were elk normally on the Sun Ranch, east of the Madison River. An ongoing late-season hunt is believed to have pushed them across to the Gravellys.

[d] This total includes 319 elk believed missed during the first flight and observed on a second flight.

[e] We counted 968 elk here on 12-20-91 with none observed in the Centennial at that time. Some of these elk may have moved back to Corral Creek in the Centennial and Price Canyon on Blacktail Ridge by 01-18-92.

[f] Of these, 109 observed in Price Canyon may be Basin-Sage Creek elk based on a neckband observed in the group.

[g] Depending upon the status of possible missed groups and extra Sun Ranch elk above, the total count could range from 6,997 to 7,793.

[h] On 03-20-94, Craig Fager counted 223 elk here.

[i] 77 of these were in Idaho; these elk are usually in Basin-Sage Cr. & Blacktail Ridge during "normal" winters.

[j] includes 126 elk in Piute Cr. to M. Fork of Blacktail Cr.

[k] probably includes elk normally in the South Centennial Valley and Blacktail Ridge

[l] exceptionally good counting conditions, especially compared to 1990-91 and 1993-94

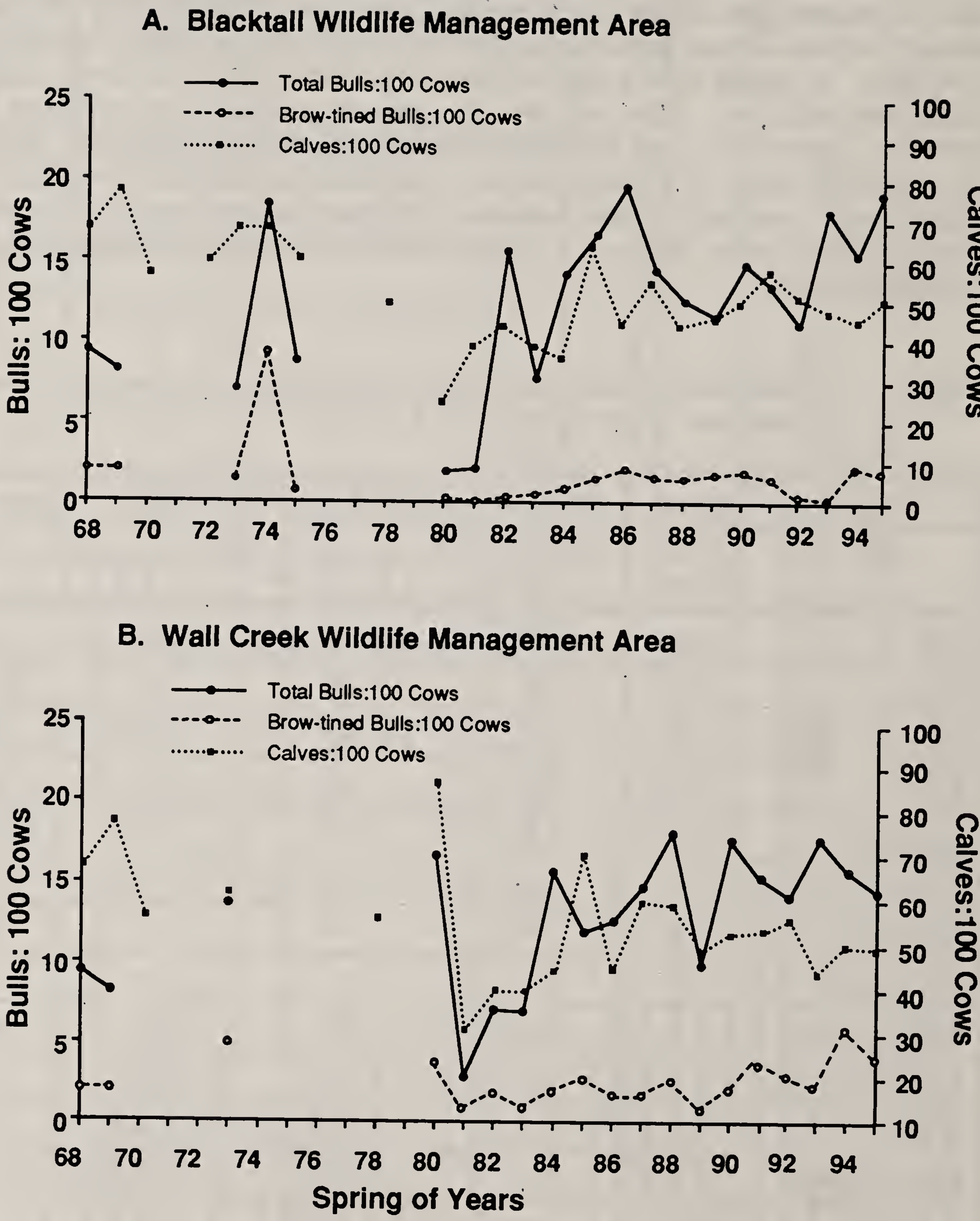
Sex and Age Structure

Classifications - Sex and age classifications made from the ground (Table 2, Fig. 3) indicated little change in calf production/survival from 1993-94. Because of mortality of radio-collared calves during March and April, some minimal reclassifications were done. A sample of 409 elk classified on the WCWMA on 04-27-95 indicated 30.2 calves/100 cows. Aerial samples of 1,446 elk obtained at Warmsprings Cr., Robb Cr., Ledford Cr., the BTWMA, and Blacktail Ridge on 04-26-95 indicated 16.3 calves/100 cows. We believe the aerial samples to be unreliable compared to the ground sample, especially this late in the year. Combined with information on mortality of radio-collared calves, however, it appears that some over-winter mortality of calves occurred this year.

Table 2. Classification results from ground observations in the Gravelly-Snowcrest Mountains, winter-spring 1995.

Area	WCWMA	BTWMA	Blacktail Ridge[a]	Basin-Sage Cr.[a]	Greenhorns[a]
Date	Jan. 26 & 27, 1995	Feb. 8 & 9, 1995	Jan. 23, 1995	Feb. 24, 1995	Feb. 6, 1995
Total	1,038	1,337	467	309	351
Cows	607	805	288	207	218
Calves	300	413	140	92	87
Bulls	131	124	39	10	46
Yearling 1X1	--	68	--	--	--
Yearling 1 X 2+	--	10	--	--	--
Raghorn Bulls	17	8	1	0	6
≥ 3 Year Bulls	2	--	--	0	--
Uncl. Ylg. Bulls	92	48	38	10	40
Calves:100 Cows	49.4	51.3	48.6	44.4	39.9
% Bulls	12.6	9.3	8.4	3.2	13.1
Bulls:100 Cows	21.6	15.4	13.5	4.8	21.1
% BA Ylgs.	--	12.8	--	--	--
Uncl. Bulls	20	--	--	--	--

[a] Classifications by Bob Brannon, FWP Biologist, Sheridan, MT.



A. Blacktail Wildlife Management Area

B. Wall Creek Wildlife Management Area

Figure 3. Sex and age structure of elk populations on the (A) Blacktail Wildlife Management Area and (B) Wall Creek Wildlife Management Area during spring, 1968-1995.

Aerial classifications (Table 3, Fig. 3) indicated a similar level of total bulls as 1993-94, but slightly fewer bulls $\geq$ 2 years. Number of bulls estimated to be $\geq$ 3 years increased. Aerial classifications of 2,996 elk made on 12-07-94 while relocating radio-collared elk included 366 yearling bulls and 20 BTB for a ratio of 12.9% total bulls and 0.7% BTB. This is slightly higher for total bulls and lower for BTB than observed on the aerial census flights (10.3% Total Bulls and 1.5% BTB, Table 3). Proportionally fewer of the older bulls may have been near the winter range so soon after the hunting season. Also most of these early classifications were of calf-cow groups.

Of a total 406 yearling bulls classified from the ground and aerially, 51 (12.6%) had an observable branch on at least one antler. One of eleven (9.1%) radio-collared yearling bulls had at least one branched antler.

Capture and Harvest

As in all previous years, reported sex ratio of calves in the harvest (51 males:66 females) favored females (Table 4). Calf sex ratios in both harvest and helicopter drive-netting have consistently indicated more females than males (Hamlin and Ross 1990b). We have not determined if these sex ratios accurately represent the population. If accurate, this may account for some of the yearling males believed to be "missing" (Hamlin and Ross 1990b).

The result for helicopter net-gun capture of calves in spring 1995 (36 males:6 females) was the same as in 1994. Overall, 161 male and 220 female calves (73:100) were captured by drive-netting and 106 male and 33 female calves (331:100) were captured by net-gunning. For the last two net-gun capture operations, 72 male and 12 female calves were captured (600:100). We have been attempting to be sex-selective by use of net-gunning, and have been successful.

The percentage of yearling females in the autumn 1994 harvest (Table 5) was similar to 1993 and lower than during 1986-1992, indicating a slight decline in calf production/survival for the past 2 years. The percentage of males older than 2 years in the harvest (21.9%) increased compared to 1993 (7.6%) as predicted (Hamlin and Ross 1994). The average age of harvested bulls $\geq$ 2 years old increased compared to 1992 and 1993 (Fig. 4).

Age structure of harvested females continued to reconcile relatively well with previous spring calf:100 cow classifications (Table 5).

Table 3. Aerial counts and classifications for the Gravelly-Snowcrest elk herds, Winter 1995.

Date	Area	Total Elk	Total Males	Total Yearling Males	Raghorns	Bulls $\geq$ 3 Years
01-23-95	Axolotl	126	15	11	3	1
01-23-95	Cherry-Morgan	533	55	48	4	3
01-23-95	Wall Creek WMA	2002	174	124	29	21
01-23-95	West Fork Madison	5	5	1	2	2
01-23-95	Sheep Creek-Mile Creek	47	5	2	3	--
East Side Gravellys Total		2713	254	186	41	27
01-24-95	North Centennial	191	51	42	8	1
01-24-95	South Centennial	82	6	6	--	--
01-24-95	Greenhorns	490	35	30	3	2
01-24-95	Warmsprings-Ruby	77	9	9	--	--
01-24-95	Piute-M. Fork Blacktail	126	18	17	1	--
01-24-95	Blacktail WMA	1621	180	163	13	4
01-24-95	Robb-Ledford	710	85	76	7	2
02-03-95	Blacktail Ridge[a]	595	51	46	5	--
02-03-95	Basin-Sage Creek[a]	1463	136	130	6	--
01-24-95	Sweetwater Hills	93	12	10	1	1
Westside Gravellys, Snowcrest, Greenhorns, and HDs 325 & 327		5448	583	529	44	10
Grand Total		8161	837	715	85	37

[a] flown and counted by Bob Brannon

Table 4. Sex and age structure of elk checked at hunter check stations and of jaws left in jaw barrels during 1994.

Age	Females		Males	
½	66[a]		51[b]	
1½	74	(17.7)[c]	2[d]	
2½	97	(23.2)	139	(78.1)
3½	65	(15.5)	31	(17.4)
4½	39	(9.3)	6	(3.4)
5½	34	(8.1)	1	(0.6)
6½	29	(6.9)	0	(0.0)
7½	19	(4.5)	1	(0.6)
8½	14	(3.3)		
9½	12	(2.9)		
10½	11	(2.6)		
11½	4	(1.0)		
12½	5	(1.2)		
13½	6	(1.4)		
14½	3	(0.7)		
15½	4	(1.0)		
16½	1	(0.2)		
17½	1	(0.2)		
18½	1	(0.2)		
unk. ≥ 1	56			
unk. ≥ 2	6			
No. ≥ 1½[e]	419			
No. ≥ 2[e]			178	

[a] number

[b] also 5 calves of unknown sex

[c] number (%) of aged 1½+ year olds

[d] 1 legal, 1 illegal

[e] aged to specific age

Table 5. Estimated percent yearling cows in autumn populations based on spring classifications and estimated calf:100 cow ratios the previous spring based on age structure of the female harvest, 1984-94.

	Calves:100 cows Spring classification	Estimated % yearling cows in autumn population based on spring classifications[a]	Estimated % yearling cows in autumn population based on age structure of hunter harvest	Estimated calves:100 cows previous spring based on harvest age structure
1984	38	16.0	17.7	43
1985	66	24.8	15.1	36
1986	42	17.4	18.8	46
1987	56	22.0	21.4	54
1988	50	19.9	22.8	59
1989	45	18.8	19.1	47
1990	49	19.7	21.7	55
1991	53	21.0	18.5	45
1992	54	21.3	21.4	54
1993	45	18.5	17.2	42
1994	48	19.4	17.7	43

[a] The projected % yearlings in the autumn population based on spring calf:100 cow ratios is calculated in the following way:

spring 1984:	38 calves:100 cows = 19 female calves:100 cows
summer-autumn 1984:	19 yearling cows/119 total cows = 0.1597

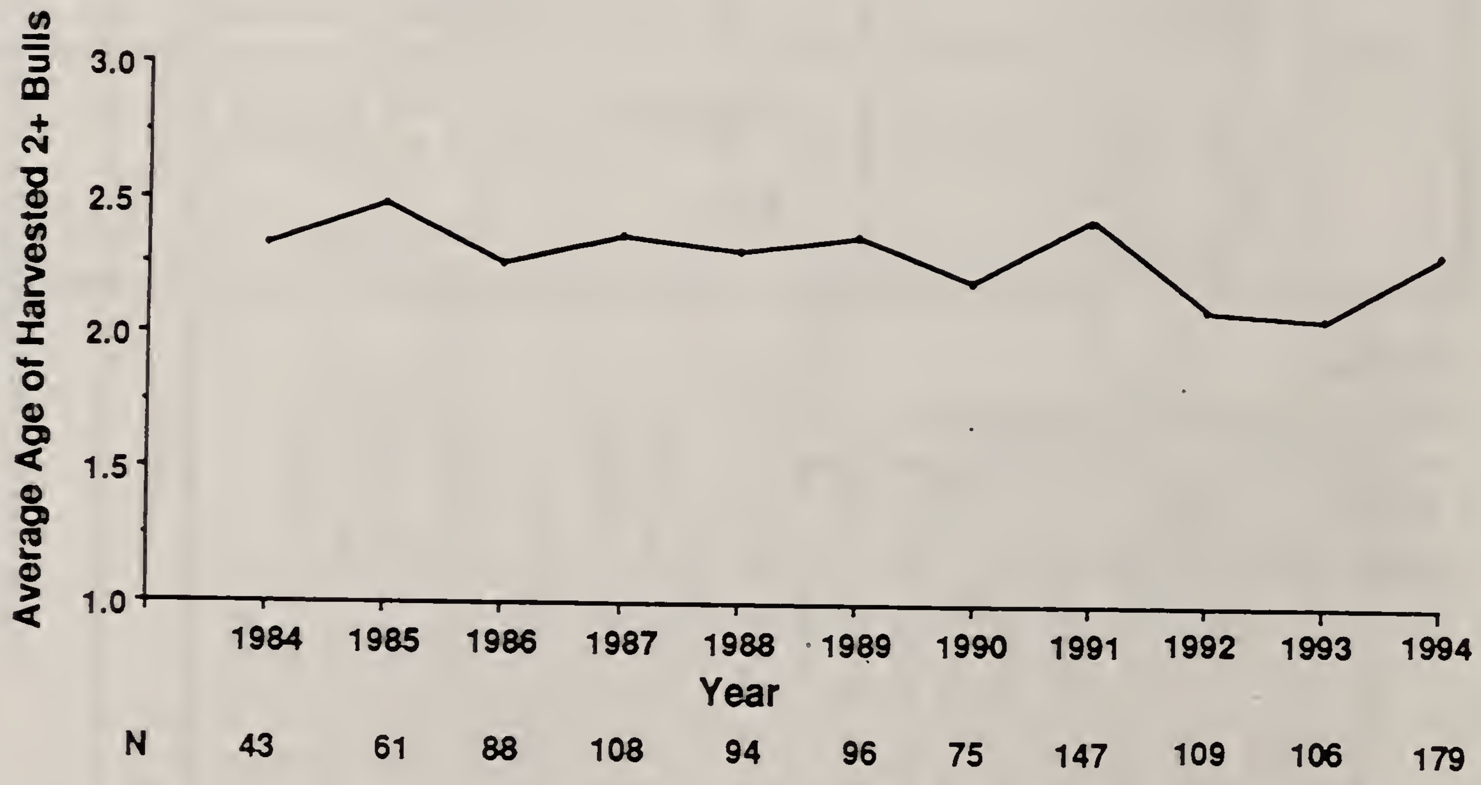


Figure 4. Average age of bulls ≥ 2 years old harvested in Gravelly-Snowcrest hunting districts, 1984-1994.

Condition Parameters

Weight and Diastema

Field dressed weights and diastema lengths of hunter-harvested calves were lower than average for both males and females (Table 6). Average weight for male calves in 1994 was the lowest recorded (Table 6). Heart-girth measurements (in.) of captured calves (Males - $\bar{X}$ = 52.1, N = 36; Females $\bar{X}$ = 50.1, N = 5) were smaller than last year, but near previous highs (Males - $\bar{X}$ = 49.4-53.9; Females - $\bar{X}$ = 48.5-52.9, Hamlin and Ross 1992). It is possible that the net-gun selection process may select for larger calves.

Table 6. Average weight and diastema length for hunter-killed elk calves in the Gravelly-Snowcrest Mountains, 1984-1995.

	Weight (lbs)		Diastema (mm)	
	Male	Female	Male	Female
1984	200.2 (5)[a]	159.1 (9)[a]	83.7 (6)[b]	79.1 (14)[b]
1985	178.0 (4)	178.7 (6)	81.8 (20)	81.7 (34)
1986	179.0 (8)	156.7 (9)	82.2 (16)	80.5 (35)
1987	172.5 (2)	150.7 (7)	82.1 (21)	84.2 (32)
1988	166.8 (9)	152.2 (10)	85.9 (9)	82.3 (21)
1989	160.8 (9)	146.8 (10)	81.1 (24)	81.7 (26)
1990	183.8 (4)	164.8 (10)	85.8 (8)	85.8 (16)
1991	163.5 (10)	153.7 (14)	83.2 (32)	82.7 (45)
1992	164.0 (11)	152.0 (8)	81.8 (21)	80.6 (25)
1993	198.8 (5)	160.6 (10)	83.6 (23)	81.7 (36)
1994	158.1 (9)	151.6 (8)	82.1 (20)	80.9 (23)
$\bar{X}$	175.0 (11 yrs)	157.0 (11)	83.0 (11)	81.9 (11)

[a] weight in lbs (sample size)
[b] diastema in mm (sample size)

Blood Chemistry and Hematology

Recently collected data are not summarized here, but will be analyzed and summarized in the final report.

Disease and Parasites

One (2.2%) of 43 blood samples collected in 1995 was a positive reactor for brucellosis. This elk was a 10-month old male calf, for which a positive reaction is unusual (K. Aune pers. comm.). We may attempt to recapture this animal during winter 1995-96 and retest it. None of the 43 elk were positive reactors for blue tongue or IBR. Sixteen (37.2% were positive reactors for BVD and 19 (44.2%) were positive reactors for PI_3. Eight (18.6%) individual elk were positive reactors for leptospirosis. One individual was positive for two different serovars. There were 5 reactors for serovar autumnalis and 3 for serovar tarasova.

Fecal samples were collected from 43 of the elk captured in March 1995. These samples were analyzed by Dave Worley (MSU Vet. Res. Lab.) with standard Baerman and fecal flotation techniques. Lungworms were found in only 1 (2.3%) of the samples. This is unusually low and may indicate the samples were frozen, which destroys first stage larvae (D. Worley, pers. comm.). The sample for 1994 indicated a 42.9% rate of occurrence.

Mortality

Adult Females

Annual mortality rate for the sample of adult females with functioning radio-transmitter collars was 27.1% (Table 7), the highest recorded since widespread samples were accomplished in 1986-87. All mortality in the current sample was attributable to hunting except one classified as unknown. That one may also have been hunting related. Retrieved hunting kill was an annual rate of 16.7%, including one archery kill. Known crippling loss was 6.3% of the female population in 1994. These data indicate a similar, but higher harvest rate than 1991, the previous record year. Check station and statewide telephone and mail harvest survey data also indicated a record harvest in 1994.

A minimum of 91.5% of the annual mortality of adult females has been hunting related during 1984-1994. Crippling loss has averaged 17.7% of retrieved, reported legal kill and 16.2% of all retrieved kill (including those where hunters removed the animal, but left the collar in the field). This is also an average annual rate of 1.9% for the adult female population.

Adult Males

Of 33 radio-transmitter collared yearling males that were accounted for prior to the 1994 BTB season, 27 (81.8%) survived. Five (15.2%) were illegally killed, and the fate of one is unknown.

Of 29 bulls $\geq$ 2 years old accounted for prior to the 1994 BTB season, 7 (24.1%) were known to have survived and twenty (69.0%) were known mortalities. Of the two remaining bulls, radio contact with one was lost during the hunting season and one was suspected to be an unreported hunter kill. Thirteen bulls were shot and reported by rifle hunters, and two by archers. Two bulls were rifle wounding losses in Montana and one in Idaho. One bull was shot by a rifle hunter and not reported. One bull died during

Table 7. Mortality rates of adult female elk ($\geq$ 1 year) based on samples with functioning radio-transmitter collars.

Time	N	Total Deaths	Shot	Crippling Loss	Shot - Not Reported	Natural[a]	Unknown	Total Hunting Related
1 June 1984 - 31 May 1985	26	2 (7.7)[b]	1	0	0	1	0	1 (3.9)[b]
1 June 1985 - 31 May 1986	52	4 (7.7)	2	1	1	0	0	4 (7.7)
1 June 1986 - 31 May 1987	59	3 (5.1)	2	0	0	1	0	2 (3.4)
1 June 1987 - 31 May 1988	64	11 (17.2)	11	0	0	0	0	11 (17.2)
1 June 1988 - 31 May 1989	64	11 (17.2)	10[c]	0	1	0	0	11 (17.2)
1 June 1989 - 31 May 1990	79	13 (16.5)	9	1	1	1	1	11 (13.9)
1 June 1990 - 31 May 1991	71	11 (15.5)	5	3	1	1	1	9 (12.7)
1 June 1991 - 31 May 1992	57	13 (22.8)	10	1	1	0	1	12 (21.1)
1 June 1992 - 31 May 1993	56	7 (12.5)	5	2	0	0	0	7 (12.5)
1 June 1993 - 31 May 1994	61	6 (9.8)	5	1	0	0	0	6 (9.8)
1 June 1994 - 31 May 1995	48	13 (27.1)	8[c]	3	1	0	1[e]	12 (25.0)
Total	637	94 (14.8)	68 (72.3)[d]	12 (12.8)[d]	6 (6.4)[d]	4 (4.3)[d]	4 (4.3)[d]	86 (91.5)[d]

[a] Natural loss includes old age, malnutrition, disease, calving problems, predation, etc.

[b] Number (%) of annual sample

[c] Includes one archery-kill

[d] Number (%) of total deaths

[e] Possibly shot and not reported

late winter of "malnutrition." This bull had a shattered femur (partially healed) and spent winter in an area of deep snow and poor forage. It is not known whether the broken femur was the result of hunter or natural causes.

Crippling loss (10 males) has averaged 8.2% of retrieved legal kill (122 males) for radio-transmitter collared bulls. This is about half the rate for females and may indicate a greater willingness to follow up shots on males than females. Similar findings were made for mule deer by Hamlin and Mackie (1989).

Calves

Calves captured in March 1995 suffered the first substantial mortality since the study began. Nine of 35 male calves were known to have died. An additional two were suspected to have died, but only their radio collars were found. One of three female calves died. Overall, 10-12 (26-32%) of 38 calves died. Causes of death were as follows: 4 mountain lion kills; 2 probable mountain lion kills, 2 bear kills and/or malnutrition losses and scavenged, 1 malnutrition loss; and 1 accident/malnutrition loss (caught in a fence but no marrow fat). Two of the mountain lion kills had relatively good marrow fat levels, and one had poor marrow fat level. Both of the bear/malnutrition losses had very low levels of femur marrow fat.

If this rate of mortality (26-32%) represented that of the population, the 49 calves:100 cows observed on the WCWMA in January would have been reduced to 33-36 calves:100 cows by late April. This is similar to the 30 calves:100 cows observed for the sample of 409 elk classified on 04-27-95. This is a small sample, however, and classifications done this late are difficult. The percent yearlings observed in the 1995 harvest will help us determine how representative and widespread this observed mortality was. Perhaps these calves were more affected by capture than in other years.

Harvest Surveys and Check Stations

Total harvest of bulls ≥ two years old increased to the highest level recorded (Fig. 5). Reported yearling bull harvest (illegal) was at a very low level. The number of hunters was at the highest level observed during 1971-1994 (Fig. 5). Excluding the years of season-type change (1981 and 1990), average bull harvest has been about 40% higher with a BTB season than for the BAB season. Populations have grown throughout the period, but harvests did not increase during the period of BAB seasons (Fig. 5).

Total antlerless harvest was a record and hunter success was at the long-term average (Table 8). Check station data (Table 9) also indicated a record level of harvest for both antlered and antlerless elk.

Abandoned elk, crippling loss, and/or illegal kill reported at check stations (Table 10) was the highest recorded for spike bulls since 1989. Estimated number of yearling bulls in the population has increased throughout the period, thus raw numbers of reported

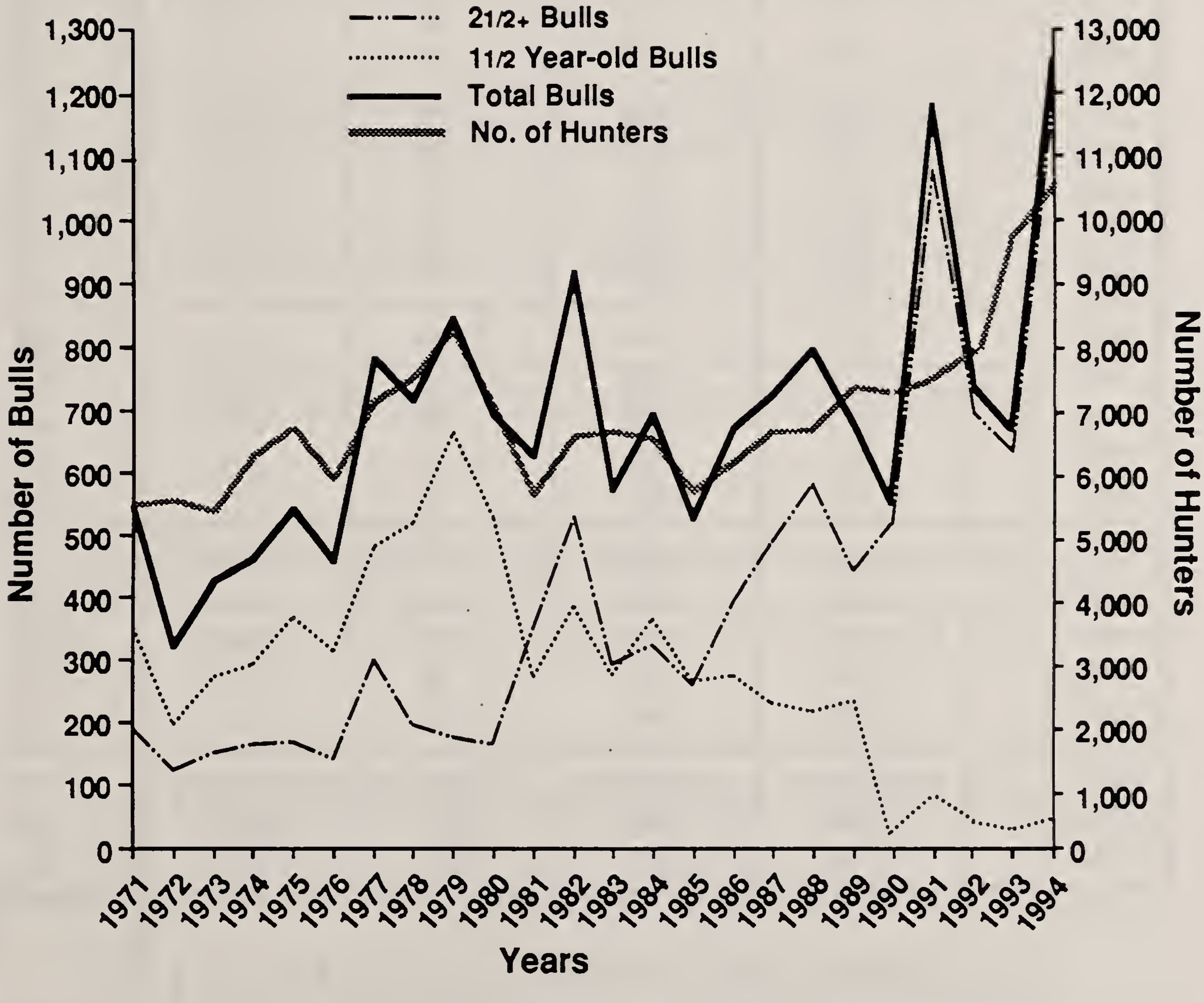


Figure 5. Numbers of hunters and harvest of total bulls, yearling bulls, and bulls ≥ 2 years old in Gravelly-Snowcrest hunting districts as estimated by statewide hunter harvest survey, 1971-1994.

Table 8. Antlerless harvest in HDs 322, 323, 324, 325, 326, 327, and 330 based on the statewide hunter harvest survey.

Year	No. of Permits	Cows Harvested	Calves Harvested	Total Harvested	Percent Success
1967	125	156	14	170	--
1968	470	290	48	338	72
1969	700	336	71	407	58
1970	735	280	33	313	43
1971	674	192	27	219	32
1972	672	189	60	249	37
1973	475	171	34	205	43
1974	300	92	17	109	36
1975	300	134	18	152	51
1976	350	138	25	163	47
1977	350	184	28	212	61
1978	716	302	39	341	48
1979	576	243	43	286	50
1980	425	195	18	213	50
1981	325	149	20	169	52
1982	725	396	29	425	59
1983	1,275	596	74	670	53
1984	1,775	719	96	815	46
1985	1,950	709	122	831	43
1986	1,500	500	89	589	39
1987	1,500	606	67	673	45
1988	1,750	771	98	869	50
1989	1,950	721	123	844	43
1990	2,000	633	79	712	36
1991	2,000	963	168	1,131	57
1992	2,420	976	132	1,108	46
1993	3,540	893	107	1,000	28
1994	3,540	1,400	213	1,613	46

Table 9. Season-long results from hunter check stations operated in the Gravelly-Snowcrest Mountains during 1984-1994.

Check Station[a]	Year	No. Hunters	Elk				Mule Deer			White-tailed Deer		
			Males		Females	Calves	Males	Females	Fawns	Males	Females	Fawns
			Yrlng.	>2								
Ruby	1984	1,698	11	23	57	11	127	100	43	20	6	3
	1985	1,623	10	46	82	27	161	105	27	19	5	3
	1986	2,172	11	42	47	14	146	93	30	33	9	18
	1987	2,135	14	36	69	18	175	83	18	26	4	7
	1988	2,096	14	39	62	19	204	62	15	17	6	9
	1989	1,832	4	28	55	27	147	43	9	19	1	3
	1990	1,830	0	34	43	15	167	56	17	17	5	1
	1991	1,522	0	50	51	21	158	74	9	9	1	3
	1992	1,738	0	47	77	23	125	69	10	18	3	6
	1993	2,019	0	56	62	19	52	63	14	10	4	4
	1994	1,964	0	60	74	22	113	92	22	8	3	2
Blacktail Road	1986	1,882	11	20	28	9	102	39	5	24	10	4
	1987	1,930	11	29	38	7	135	38	10	18	10	7
	1988	1,831	11	25	53	3	136	38	9	21	11	7
	1989	2,256	14	40	48	23	137	42	11	26	4	9
	1990	1,781	1[b]	22	34	9	99	66	11	13	2	1
	1991	1,887	1	60	77	21	105	74	9	9	1	3
	1992	2,214	1[b]	40	64	18	118	93	19	29	13	3
	1993	2,045	0	28	37	14	63	101	30	19	14	9
	1994	2,051	0	83	72	24	74	73	20	9	9	9
Ennis	1986	2,177	11	27	24	7	61	23	11	6	0	0
	1987	1,010	6	28	28	8	66	14	4	5	0	1
	1988	1,017	11	31	63	17	110	12	4	8	2	2
	1989	913	8	29	33	8	53	13	0	5	3	1
	1990	897	1[b]	27	42	6	46	16	6	1	0	1
	1991[c]	678	0	41	46	19	53	21	5	7	2	-
	1992	909	0	31	42	12	54	21	4	1	5	0
	1993	901	0	36	37	7	30	23	8	4	4	1
	1994	1,106	1[b]	63	82	13	31	31	8	4	5	1

Table 9 continued.

Check Station[a]	Year	No. Hunters	Elk				Mule Deer			White-tailed Deer		
			Males									
			Yrlng.	≥2	Females	Calves	Males	Females	Fawns	Males	Females	Fawns
All	1984	3,425	16	40	97	25	154	106	51	26	6	3
	1985	3,124	12	72	110	31	214	121	29	23	5	3
	1986	6,231	33	89	99	30	309	155	46	63	19	22
	1987	5,075	31	93	135	33	376	135	32	49	14	15
	1988	4,944	36	95	178	39	450	112	28	46	19	18
	1989	5,001	26	97	136	58	328	98	20	50	8	13
	1990	4,508	2[b]	81	119	30	312	138	34	31	7	3
	1991[c]	4,087	1	151	174	61	316	162	23	38	20	8
	1992	4,861	1[b]	118	183	53	297	183	33	48	21	9
	1993	4,965	0	120	136	40	145	187	52	33	22	14
	1994	5,121	2[d]	205	228	59	218	196	50	21	17	12

[a] The Upper Ruby Creek Check Station was the only one operated each year 1984-1989. In 1984 and 1985, 2-3 other stations were manned on the east side of the Gravellys. In 1986, those were combined into one station at Ennis and a new station was opened on the Blacktail Road south of Dillon.

[b] Illegal kill.

[c] Ennis check station not operated opening day in 1991.

[d] 1 legal, 1 illegal

Table 10. Crippling loss, abandoned elk, and/or illegal kill reported at check stations.

Year	Yearling Bulls	Legal Bulls	Adult Females	Calves	Illegal Yearling Bulls/ Total Yearling Bulls[a]
1988	82	6	27	5	11.1%
1989	41	2	36	3	4.8%
1990	28	4	38	3	2.2%
1991	18	2	19	1	1.2%
1992	26	2	11	1	1.7%
1993	21	8	15	6	1.4%
1994	38	6	16	8	2.3%

[a] Total number of reported abandoned yearling bulls (including duplicates) divided by estimated total number of non-legal yearling bulls in the population X 100.

illegal kills are not comparable. For instance, roughly 850 spikes (BA yearlings were legal) were present preseason in 1989 and an estimated 1,635 yearling bulls were present preseason in 1994. Thus, the 41 illegal yearlings reported in 1989 represented 4.8% of the available population and the 38 illegal spikes reported in 1994 represent 2.3% of the available population (Table 10). Although the total illegal kill reported in 1994 was up compared to that of 1990-1993, the rate was less than that of 1988 and 1989.

Antler Characteristics

The ongoing test of the hypothesis that increasing survival of larger, branch-antlered yearlings will result in larger antlered older bulls (Hamlin and Ross 1992) continued. Data collected thus far (Table 11) does not indicate major differences thus far pre- and post-treatment, though statistical tests have not been completed.

Hunter Opinion Survey

In 1984, three years after the branch-antlered bulls regulation was implemented, an opinion survey was sent to hunters who indicated at check stations that they would respond to the mailing (Lonner and Schladweiler 1986). Although hunters were randomly asked to participate, surveys were sent only to willing participants, which results in a non-random survey. This method may be more likely to sample cooperative people and also those who want to share strongly held views than would occur with a random sample. This same method was used to obtain samples for opinion surveys in 1989 (last year of BAB hunting) and 1994 (fourth year of BTB hunting).

Table 11. Number of points per side and main beam length of 2-5-year-old bulls harvested in the Gravelly-Snowcrest Mountains under branch-antlered bull regulations and brow-tined bull regulations, 1984-1994. Beam length in millimeters.

Age	Antler Characteristic	Pre-treatment (BAB) 1984-1990	Post-treatment (BTB) 1991-1994
2½	Points/side	$\bar{X}$ = 4.54 N = 818 (411)[a]	$\bar{X}$ = 4.51 N = 834 (424)
	Main Beam Length	$\bar{X}$ = 753.8 N = 790 (397)	$\bar{X}$ = 747.9 N = 797 (416)
3½	Points/side	$\bar{X}$ = 5.24 N = 71 (36)	$\bar{X}$ = 5.32 N = 80 (41)
	Mean Beam Length	$\bar{X}$ = 854.5 N = 66 (34)	$\bar{X}$ = 886.0 N = 78 (40)
4½	Points/side	$\bar{X}$ = 5.90 N = 21 (11)	$\bar{X}$ = 5.71 N = 14 (7)
	Mean Beam Length	$\bar{X}$ = 1028.3 N = 20 (11)	$\bar{X}$ = 1045.5 N = 13 (7)
5½	Points/side	$\bar{X}$ = 6.10 N = 10 (5)	
	Mean Beam Length	$\bar{X}$ = 1127.0 N = 5 (3)	

[a] Number of antlers (number of individuals); because of broken or deformed antlers, number of antlers is not always twice the number of individuals.

In 1994, 422 questionnaires were mailed and 267 (266 usable) were returned for a response rate of 63.3%. Responses to questions that we asked in at least two of the three years (Table 12) indicated similar responses in 1984 and 1989, but changes were observed in 1994 (Table 12).

Composition of the hunter sample was similar for all three years (Table 12). Nonresidents comprised 12.8% of the sample in 1994 with Washington and California the predominant states. Resident respondents were from 54 Montana towns throughout the state. The largest samples were from: Butte - 18.3%; Dillon - 14.1%; Billings - 9.9%; Bozeman - 6.1%; and Ennis - 4.2%.

Years hunted ranged from 1 to 56 with about 75% having hunted for seven years or more. Ten percent had never killed an elk, and 36.1% had killed 1-4 elk during their lives. Days hunted ranged from 1 to 35; 51.5% hunted six days or less. Sixty-four percent of the hunters had hunted in Gravelly-Snowcrest hunting units for 5 years or more, and 83% had shot an elk there.

Table 12. Responses of hunters during 1984, 1989, and 1994 to questions asked about their hunting experience in the Gravelly-Snowcrest Mountains.

	1984	1989	1994
Number of Respondents	280	249	266
% of hunters that were males	97.9	97.5	97.0
% Nonresidents	12.0	3.6	12.8
% that killed an elk	20.0	37.0	57.1
% that also archery hunted	10.0	12.0	11.3
Quality of hunt (1=poor - 10=excellent)	5.7	6.1	7.3
% paying for full outfitter services	0.7	0.0	0.4
% paying for drop camp services	1.0	0.0	0.4
% paying for packing elk out	1.0	0.0	4.3
% paying for horse rental	1.8	1.2	2.4
% thinking that during the last 5 years total elk in the population has:			
increased	22.2	29.3	37.4
been stable	52.6	49.5	53.9
decreased	25.1	21.2	8.7
As above, except total bulls:			
increased	23.7	20.9	37.8
been stable	37.7	43.6	48.4
decreased	38.7	35.5	13.8
As above, except total branch-antlered/brow-tined bulls:			
increased	21.3	19.6	40.1
been stable	34.8	37.4	40.5
decreased	44.0	42.9	19.4
% satisfied with opportunity to see a branch-antlered bull	58.6	48.1	74.2
% satisfied with killing an elk regardless of sex or age	48.3	54.1	57.9
% satisfied with existing regulations	70.0	64.5	81.0
% observing yearling bulls illegally or accidentally shot and left or shot and taken home	NA[a]	33.7	26.1
% reporting observation of yearling bulls taken home	NA	6.0	5.6
Numbers per hunter of reported yearling bulls:			
shot and left	NA	0.79	0.34
shot and taken home	NA	0.09	0.09

[a] NA = not asked, non-applicable

Fifty-seven percent of the sample had killed an elk in 1994 compared to 20% in 1984 and 37% in 1989. These are higher percentages of success than observed for the general hunter population; therefore, it is likely that successful hunters are responding to this survey at higher rates than unsuccessful hunters.

The following percentage of hunters spent at least some time hunting by use of the following: vehicle 62%, vehicle with limited travel on foot 17%, foot travel 90%, horseback 21%, trail bike 0%, ATV 10%, and snowmobile 7%. The composite percent time by each method for all hunters in the sample was: vehicle 17.3%, vehicle with limited travel on foot 6.3%, foot travel 61.8%, horseback 12.2%, trailbike 0%, ATV 1.5%, and snowmobile 0.8%. All these data were almost identical to that of 1989.

Similar to previous years, very few in the sample paid for outfitter services. Payment for packing out elk or horse rental may be increasing, however.

The percentage of hunters that also hunted elk in the Gravelly-Snowcrest Mountains by archery was about the same each year (Table 12).

One of the biggest changes among years of the survey was the increased perception by hunters that total elk, total bulls, and especially brow-tined bulls had increased in the last 5 years (Table 12). These differences were even more dramatic for hunters who had hunted in the Gravelly-Snowcrest Mountains for 5 years or more. This perception accurately reflects what has occurred in the elk population.

On a scale of 1 to 10 (1=poor, 10=excellent), hunters ranked the quality of their 1994 hunt an average of 7.3 compared to 6.1 in 1989 and 5.7 in 1984. Similar to prior years, successful hunters ranked the quality of their hunt higher (8.0) than unsuccessful hunter (6.4). These numbers were higher in both categories than in previous years; even unsuccessful hunters in 1994 ranked the quality of their hunt higher (6.4) than all hunters in 1989 (6.1) and 1984 (5.7). Thus, even accounting for increased numbers of successful hunters in 1994, an increase in reported quality of the hunt has occurred.

In 1994, 74% of hunters were satisfied with the current opportunity to see brow-tined bulls compared with only 59% in 1984 and 48% in 1989 (Table 12). Eighty-one percent of hunters were satisfied with existing regulations in 1994 compared to 65% in 1989 and 70% in 1984. These opinions may reflect a more positive perception of the brow-tined bull regulation than the branch-antlered bull regulation along with increased numbers of elk.

A 23% decline occurred between 1989 and 1994 in the percentage of hunters reporting having observed yearling bulls illegally or accidentally shot and left or shot and taken home (Table 12). The percentage reporting observations of yearling bulls illegally shot and taken home was about the same both years (Table 12). The number of yearlings reported shot and left declined 57%, but the rate of those reported shot and taken home did not decline (Table 12). This seems to indicate that the BTB regulation has reduced accidental kill of yearling bulls as hoped, but intentional kill of yearlings has been relatively unaffected (as expected). Yearling bulls comprised 54% of the 168 elk reported shot and left lay in the field in this survey and 56% of those reported at check stations.

Sixty-three percent of hunters responding to the questionnaire also hunted deer in the Gravelly-Snowcrest hunting units. Thirty-one percent killed a deer. Eighty-five percent of the deer killed were mule deer; 64% were bucks and 36% does. Forty-three percent of the respondents do most of their deer hunting in Gravelly-Snowcrest hunting units. Sixty-eight percent of respondents mainly hunted the Gravelly-Snowcrest area for elk, only 1.6% mainly for deer, and 31% equally for both elk and deer. Seventy percent of respondents would not hunt deer in this area if they could not hunt elk there. If they were not allowed to hunt deer in this area, 96.5% of respondents would continue to hunt elk there.

Common responses to the open-ended question asking for any other opinions about elk management in the Gravelly-Snowcrest Mountains are presented in Table 13. These responses are listed in descending order of frequency for the 1984 survey and compared with response rate for 1989 and 1994. Fewer people gave additional comments in 1989 and 1994 than in 1984.

In all years, problems with off-road vehicle use, including requests for greater enforcement of existing regulations, has been the number one issue of concern. Related to this, requests for more motorized game retrieval opportunities and requests for more open roads are also common (Table 13). As the elk population and hunter success has increased, there has been an increase in the comments indicating satisfaction with MFWP management.

Generally, the questionnaire results indicate support for and satisfaction with changes in elk management made by MFWP. This could change if elk populations and/or hunter success declines.

Table 13. Summary of responses to the open-ended question about elk management in 1984, 1989, and 1994 hunter opinion surveys for Gravelly-Snowcrest hunters. Expressed as a percent of total questionnaires returned.

Year	1984	1989	1994
Total sample size	280	249	266
No comments	22.9	52.2	50.6
Expressed problems with ATVs/snowmobiles	16.1	4.4	8.2
Pleased with BAB regulation	15.7	0.8	NA[a]
Too many closed roads/need more access	11.4	3.6	5.2
Need more MFWP/USFS presence and more enforcement/higher fines	7.1	6.8	5.2
Limit nonresident hunters	6.4	4.4	2.6
Need more motorized game retrieval opportunities	6.4	2.8	6.0
Put all elk hunting including bulls on permits (drawing)	6.1	2.4	1.9
Problems with private land blocking access to public land	6.1	1.2	2.6
Issue more cow permits	5.0	1.2	0.8
Allow any bull to be shot	5.0	0.8	3.0
Close bull season for 1-5 years	4.3	0.8	0.8
Close more roads/trails	3.2	3.6	3.4
Pleased with MFWP management	2.9	4.4	8.2
Antlerless tag holder should not be allowed to shoot bulls	2.5	4.4	NA
Close/restrict archery hunting	2.1	1.6	1.5
Restrict horseback access	2.1	1.6	--
Problems with illegal/rude/etc. outfitters	1.4	2.4	1.1
Issue fewer cow permits	1.4	--	2.6
Institute a muzzleloader season	1.1	--	1.5
Reduce cattle grazing	0.7	3.6	1.9
Stop split antlerless seasons	1.1	0.8	1.1
Against prohibiting antlerless hunters from shooting a bull in their district	NA	NA	4.5
Fewer deer than in past	--	--	1.9

NA = non-applicable

LITERATURE CITED

Chrest, H., and J. Herbert. 1980. Statewide wildlife survey and inventory in Big Game Survey and Inventory, Region Three. Unpubl. P-R Job Prog. Rept., Montana Dept. Fish, Wildlife and Parks, Helena. Montana Proj. W-130-R-11, Job I-3. 118 pp.

_____. 1981. Statewide wildlife survey and inventory in Big Game Survey and Inventory, Region Three. Unpubl. P-R Job Prog. Rept., Montana Dept. Fish, Wildlife and Parks, Helena. Montana Proj. W-130-R-12, Job I-3. 105 pp.

DeSimone, R. M., and J. Vore. 1992. Elkhorn Mountains elk monitoring program. Unpubl. P-R Job Rept., Montana Dept. Fish, Wildl. and Parks, Helena. 110 pp.

Eustace, C. D. 1967. Food habits, range use and relationships between elk and livestock in the Gravelly Mountains, Montana. MS Thesis, Montana State Univ., Bozeman. 55 pp.

French, C. E., L. C. McEwen, N. D. Magruder, R. H. Ingram, and R. W. Swift. 1956. Nutrient requirements for growth and antler development in the white-tailed deer. J. Wildl. Manage. 20:221-232.

Gilbert, F. F. 1966. Aging white-tailed deer by annuli in the cementum of the first incisor. J. Wildl. Manage. 30:200-202.

Gniadek, S. J. 1987. Elk and cattle relationships on summer range in southwestern Montana. Unpubl. M.S. Thesis, Univ. of Montana, Missoula. 63 pp.

Hamlin, K. L, and R. J. Mackie. 1989. Mule deer in the Missouri River Breaks, Montana - a study of population dynamics in a fluctuating environment. Fed. Aid in Wildl. Restor., Job Compl. Rept., Proj. W-120-R. Mont. Dept. Fish, Wildl. and Parks, Helena. 401 pp.

Hamlin, K. L., and M. S. Ross. 1990a. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-120-R-19/20. 27 pp.

_____. 1990b. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-120-R-21. 77 pp.

_____. 1991. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-120-R-22. 29 pp.

_____. 1992. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-120-R-23. 27 pp.

_____. 1993. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-100-R-1. 24 pp.

_____. 1994. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job Prog. Rept., Proj. W-100-R-2. 35 pp.

Hines, W. W., and J. C. Lemos. 1979. Reproductive performance by two age-classes of male Roosevelt elk in southwestern Oregon. Ore. Dept. of Fish and Wildl. Res. Rept. No. 8. 54 pp.

Lonner, T. N., and P. Schladweiler. 1985. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job. Prog. Rept., Proj. W-120-R-16. 22 pp.

_____. 1986. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildl. and Parks, Helena. Fed. Aid Job. Prog. Rept., Proj. W-120-R-17. 26 pp.

_____. 1987. Elk population dynamics and breeding biology. Montana Dept. Fish, Wildlife and Parks, Helena. Fed. Aid Job. Prog. Rept., Proj. W-120-R-18. 26 pp.

Prothero, W. L., J. J. Spillett, and D. F. Ralph. 1979. Rutting behavior of yearling and mature elk: some implications for open bull hunting. Pages 160-165 in Boyce, M. S., and L. D. Hayden-Wing, eds., North American Elk: Ecology, Behavior and Management. Univ. of Wyoming, Laramie. 294 pp.

Quimby, D. C., and J. E. Gaab. 1957. Mandibular dentition as an age indicator in Rocky Mountain elk. J. Wildl. Manage. 21:435-451.

Smith, J. 1980. Managing elk in the Olympic Mountains. Pages 67-111 in W. Macgregor, ed., Proc. West. States Elk Workshop, Cranbrook, B.C., Feb. 27-28, 1980.

Wildlife Division: MDFWP. 1967-1994. Annual elk hunting and harvest reports.

Wildlife Division: MDFWP. 1985. Antlered elk and deer management in Montana: past trends and current status. A special report for the Fish and Game Commission, Montana Dept. Fish, Wildl. and Parks, Helena. 68 pp.

Wood, A. K., R. E. Short, A. Darling, G. L. Dusek, R. G. Sasser, and C. A. Ruder. 1986. Serum assays for detecting pregnancy in mule and white-tailed deer. J. Wildl. Manage. 50: 684-687.